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(54) Thermal image detecting system.

(57) A thermal image detecting system is constructed by a moving part (6) including a pyroelectric thermal detection element (1), a chopper (3) for opening/closing a path of infrared rays and a chopper temperature detection element (4), a rotating section (7) for rotating the moving part, a drive control section (9) for driving the chopper (3) and the rotating section (7), a band amplifier (10) for amplifying a detection signal from the pyroelectric thermal detection element (1), a timing output section (11) for outputting a signal synchronous with an opening/closing operation of the chopper(3), a peak detection section (12) for successively holding the maximum value and the minimum value of a signal from the band amplifier (10), and an operational processing section (13) for performing an operational processing to a thermal image signal on the basis of a difference between the maximum value and the minimum value or a difference between a reference signal from the band amplifier (10) in a closed state of the chopper (3) and the maximum value or the minimum value and the temperature of the chopper (3).

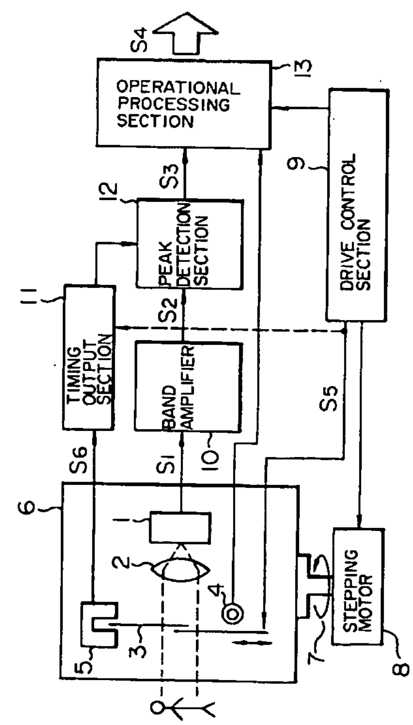

FIG. 1

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BACKGROUND OF THE INVENTION

The present invention relates to a thermal image detecting system using a pyroelectric type thermal detection element provided, for example, for the detection of the distribution of room temperatures in a general house or the detection of the behavior of a human body.

The conventional non-contact temperature measuring system includes a quantum type infrared ray sensor and a thermal infrared ray sensor. The former sensor or the quantum type infrared ray sensor is characterized in that the sensitivity is high and hence the speed of response is rapid. However, the sensor is required to be cooled (to about - 200°C). Therefore, this sensor is unsuitable for public use. On the other hand, the latter sensor or the thermal infrared ray sensor has a relatively low sensitivity and a slow speed of response but is not necessary to be cooled. Therefore, this sensor is put to practical use in the market of public use. In particular, a pyroelectric type infrared ray sensor using the pyroelectric effect is widely used.

The pyroelectric infrared ray sensor has a differential change output characteristic so that an output is generated only when the incident temperature changes. In the pyroelectric infrared ray sensor hitherto placed to practical use, a Fresnel lens using a polyethylene resin and having the angle of view having a light distribution characteristic is provided on the entire surface of the sensor. When a human body moves, the radiation temperature of the human body is inputted as a time changing input in accordance with the light distribution characteristic. An output of the pyroelectric infrared ray sensor is provided in synchronism with the time changing input, thereby making it possible to detect the human body. On the other hand, when the human body is in a stationary state, the detection of the human body is not possible since the time changing input is not provided.

Also, there are a pyroelectric infrared sensor which is made of ceramics and a point temperature sensor which uses a chopper. However, since these sensors have a low sensitivity and a very slow speed of response, it is not possible to detect several-tens temperature data in one or two seconds. Further, there is considered a system in which pyroelectric infrared sensors are two-dimensionally arranged as temperature distribution measuring means.

SUMMARY OF THE INVENTION

In the conventional method, though the detection of a moving human body is possible, the position of the human body and a human body in a stationary state cannot be detected and the measurement of the temperature of an object other than a human body, for example, the measurement of a temperature distribution of a wall or floor in a room is impossible. Also, the system, in which pyroelectric infrared sensors are two-dimensionally arranged, has a problem that the system construction becomes complicated.

One object of the present invention is to provide a system in which a thermal image having a wide angle of view can be detected with a relatively simple system construction. Another object of the present invention is to improve the performance of a thermal image detecting system by performing a processing for highly-precise detection of a differential change characteristic outputted by a pyroelectric infrared ray sensor.

To that end, a thermal image detecting system according to one aspect of the present invention comprises a moving part including a pyroelectric thermal detection element, a chopper for opening/closing a path of infrared rays and a chopper temperature detection element, a rotating section for rotating the moving part around a predetermined rotation axis, a drive control section for driving the chopper and the rotating section, a band amplifier for amplifying a detection signal from the pyroelectric thermal detection element, a timing output section for outputting a signal synchronous with an opening/closing operation of the chopper, a peak detection section for successively holding the maximum value and the minimum value of a signal from the band amplifier in accordance with an output of the timing output section, and an operational processing section for performing an operational processing to a thermal image signal on the basis of a difference between the maximum value and the minimum value and a detection signal of the chopper temperature detection element.

According to this thermal image detecting system, there is provided a thermal image detecting system with a small size and a simple construction in which a detection signal from the pyroelectric thermal detection element is amplified while rotating the moving part including the pyroelectric thermal detection element and the chopper so that the maximum value and the minimum value of the detection signal are detected at a fixed timing for each opening/closing operation of the chopper and a difference between the maximum value and the minimum value is operationally processed to obtain a thermal image signal.

In the thermal image detecting system, a reference signal detection section for detecting a signal from the band amplifier in a closed state of the chopper may be provided so that the operational processing section performs an operational processing to a thermal image signal on the basis of a difference between the maximum value or the minimum value from the peak detection section and the reference signal from the reference signal detection section. Thus, the thermal image signal can be obtained by an operational processing based on a difference between a reference signal in a constant closed state of the

chopper and the maximum value or the minimum value for each opening/closing operation of the chopper. Accordingly, the problem of a speed of response of the band amplifier to amplify a detection signal from the pyroelectric thermal detection element can be moderated, thereby making it possible to improve the degree of freedom of design of a band amplifier and the precision of detection of a thermal image.

In the thermal image detecting system, a plurality of pyroelectric thermal detection elements may be arranged in the form of a row as a pyroelectric thermal detection element group with the band amplifiers and so on being provided with the same number as the plurality of pyroelectric thermal detection elements, thereby detecting a two-dimensional thermal image. In this case, since a two-dimensional thermal image signal can be obtained in lieu of a one-dimensional thermal image signal, the capacity of detection of a temperature distribution, a human body position and so on is improved greatly.

In the thermal image detecting system, an input signal of the timing output section may be a chopper driving signal from the drive control section for driving the chopper. In this case, a simple construction becomes possible in such a manner that timings for detection of the maximum value and the minimum value for each opening/closing operation of the chopper are taken by the chopper driving signal.

In the thermal image detecting system, an opening/closing detection sensor for detecting the actual opening/closing of the chopper may be provided in the moving part so that a detection signal from the opening/closing detection sensor is used as an input signal of the timing output section. In this case, since the opening/closing detection sensor is provided to detect the actual opening/closing of the chopper, the precision of detection of a signal from the pyroelectric thermal detection element can be improved and the detection of a failure of the chopper becomes possible.

In the thermal image detecting system, closing means for bringing the chopper to a closed state at the time of no supply of a current to the chopper may be provided. In this case, since the chopper is always brought to the closed state, the pyroelectric thermal detection element or the pyroelectric thermal detection element group is prevented from being irradiated with unnecessary infrared rays in a period of time when the detection of a thermal image signal is not conducted. Further, when the reference signal detection section detects the reference signal, the supply of a current for obtaining a closed state of the chopper becomes unnecessary. Therefore, power saving can be attained and an unnecessary temperature rise of the chopper and in the vicinity thereof can be reduced.

In the thermal image detecting system, the drive control section may be provided with a first timer and a second timer. The drive control section maintains the chopper at a closed state during the period of the first timer and thereafter causes the reference signal detection section to detect a reference signal in the period of the second timer. After the completion of the second timer, the moving part is rotated and an opening/closing operation of the chopper is performed. In this case, since the detection of the reference signal in the constant closed state of the chopper is made before the moving part is rotated, it is possible to avoid a temperature rise of the chopper and in the vicinity thereof, the influence of noises caused by the rotation operation of the moving part, and so on. As a result, the precision of thermal image detection can be improved.

In the thermal image detecting system, the timer period of the first timer may be longer than at least two times as large as the opening/closing period of the chopper. In this case, since the chopper is placed at the above-mentioned constant closed state in a period of time longer than at least two times as large as the opening/closing period of the chopper, an output signal from the band amplifier can be stabilized entirely, thereby making it possible to detect the reference signal with a higher precision.

In the thermal image detecting system, the reference signal detection section may be provided with averaging means which is inputted with a signal from the band amplifier plural times in a closed state of the chopper to calculate an average value of the plural signals inputted. In this case, since the detection of the reference signal is conducted plural times to determine the average value, there is provided an effect that the influence of external noises on the reference signal is reduced greatly.

In the thermal image detecting system, there may be employed a construction in which the timing output section provides an output in a predetermined period of time in the vicinity of an instant of time of change from a closed state of the chopper to an opened state thereof and the peak detection section includes a polarity detection section so that the maximum value or the minimum value is detected in accordance with the detected polarity. In this case, since the detection of the maximum value or the minimum value is conducted in the vicinity of the instant of time of change from the closed state of the chopper to the opened state thereof, the detection of the maximum value or the minimum value can be performed precisely and in a short time, thereby enhancing the degree of freedom of design concerning a signal processing time.

In the thermal image detecting system, the peak detection section may be constructed by a pair of analog peak hold sections and a time instant detection section for the maximum value and the minimum value. Also, the peak detection section may be constructed by an A/D conversion section, a pair of digital

peak hold sections and a time instant detection section. Thus, the peak detection section can be constructed by either an analog circuit or a digital circuit. There is an effect that one of the analog circuit and the digital circuit can be selected properly to rationalize the construction of the whole of the system.

In the thermal image detecting system, there may be employed a construction in which an average value between the maximum or minimum value detected in the digital peak hold sections and the previous maximum or minimum value is sequentially determined. Also, the peak detection section can be constructed by an A/D conversion section, an average value holding section for operating an average value between the preceding output value of the A/D conversion section and the present output value thereof and holding the average value, and a pair of digital peak hold sections for detecting the maximum value and the minimum value of an output value of the average value holding section and holding them, respectively. In the case where the digital peak hold sections are used, two means for determining the maximum value or the minimum value by calculating an average value of values before and after are possible. When peak noises such as power supply noises, external noises or the like enter a signal from the pyroelectric thermal detection element or the band amplifier, the influence of these noises can be reduced through the averaging process. In other words, the averaging process contributes to the detection of a thermal image signal with a high precision.

As apparent from the foregoing, the present invention provides excellent effects as industrial products, that is, effects that a one-dimensional or two-dimensional thermal image can be detected with a relatively simple construction and a high precision and the invention can be used widely for the detection of a temperature distribution, a human body, the position or behavior of the human body, and so on with a low-cost system.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the construction of a thermal image detecting system according to an embodiment of the present invention;

Fig. 2 is a timing chart for explaining the operation of the thermal image detecting system shown in Fig. 1;

Fig. 3 is a block diagram showing the construction of a thermal image detecting system according to another embodiment of the present invention;

Fig. 4 is a timing chart for explaining the operation of the thermal image detecting system shown in Fig. 3;

Fig. 5 is a timing chart for explaining the operation of a thermal image detecting system according to a further embodiment of the present invention; and

Fig. 6 is a diagram showing an example of the construction a pyroelectric thermal detection element group.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A thermal image detecting system according to the present invention will now be explained in reference to the accompanying drawings.

First, the construction of a thermal image detecting system according to an embodiment of the present invention will be explained by use of Fig. 1. In the figure, reference numeral 1 designates a pyroelectric thermal detection element which has an electric characteristic changing in response to infrared rays, numeral 2 an infrared ray transmitting lens provided on a front surface of the pyroelectric thermal detection element 1 for transmitting infrared rays from a desired area, numeral 3 a chopper for opening/closing a path of infrared rays from an object to be detected (for example, a human body) to the pyroelectric thermal detection element 1, numeral 4 a chopper temperature detection element for detecting the temperature of the chopper 3, and numeral 5 an opening/closing detection sensor for detecting the actual opening/closing operation of the chopper 3. These constituent elements 1 to 5 form a moving part 6. Numeral 7 designates a rotating section for rotating the moving part 6 around a predetermined rotation axis in a predetermined range, for example, a range of 150°. The rotating section 7 includes a stepping motor 8 or the like. Numeral 9 designates a drive control section for driving the chopper 3 and the stepping motor 8, and numeral 10 designates a band amplifier which is inputted with a minute detection signal S1 from the pyroelectric thermal detection element 1 and has the maximum amplification degree, for example, about 60 to 80 dB, in the vicinity of a frequency equal to the opening/closing frequency of the chopper 3. Numeral 11 designates a timing output section which is inputted with an opening/closing detection signal S6 from the opening/closing detection sensor 5 to output the timing of detection of an output signal S2 of the band amplifier 10, numeral 12 a peak detection section for successively holding the maximum value and the minimum value of the output signal of the band amplifier 10 for each opening/closing operation of the chopper 3, and numeral 13 an operational processing section which is inputted with an output signal S3 from the peak detection section 12 to obtain a difference between the maximum value and the minimum value and is inputted with a detection signal from the chopper temperature detection element 4 to perform an operational processing to a thermal image signal on the basis of the detection signal and the difference

between the maximum value and the minimum value.

Next, explanation will be made of the operation of the system shown in Fig. 1. Fig. 2 is a timing chart for explaining the operation of the construction shown in Fig. 1. First, the drive control section 9 outputs driving signals to the chopper 3 and the rotating section 7 so that the moving part 6 is rotated, for example, by about 0.3° at every 4 ms and the chopper 3 is opened/closed, for example, at 32 Hz. The chopper driving signal S5 is a signal which has an opening/closing period of Tc and has the actual opened state and closed state about half and half. The opening/closing detection sensor 5 detects the opening/closing operation of the chopper 3 to output an opening/closing signal S6 as shown in Fig. 2. The actual operation of the chopper 3 has a response delay of Td for the chopper driving signal. In accordance with the opening/closing operation of the chopper 3, the pyroelectric thermal detection element 1 is inputted with the temperature of the chopper 3 when the chopper 3 is in a closed state and with the temperature of an object such as a human body to be detected when the chopper 3 is in an opened. The pyroelectric thermal detection element 1 continuously provides as a detection signal S1 a differential change output which is substantially proportional to a differential temperature ΔT (= the temperature of the object to be detected minus the temperature of the chopper 3). The band amplifier 10 amplifies the detection signal S1 to provide an output signal S2 as shown in Fig. 2. The output signal S2 has a characteristic as shown by solid line in Fig. 2 when the differential temperature ΔT is positive and a characteristic as shown by broken line when the differential temperature ΔT is negative. In the output signal S2 of the band amplifier 10, a difference between the maximum value V1 and the minimum value V2 of the output signal S2 in a period K1' corresponding to the actual opening/closing operation period of the chopper 3, for example, a period K1 shown in Fig. 2 , that is, V1 - V2 is substantially proportional to the differential temperature ΔT. A period K2' corresponds to a period K2. The maximum value V1 (or the minimum value V1 when $\Delta T < 0$) appears in the vicinity of an instant of time tl at which the chopper 3 is brought from its opened state to its closed state, and the minimum value V2 (or the maximum value V2 when $\Delta T < 0$) appears in the vicinity of an instant of time t2 at which the chopper 3 is brought from its closed state to its opened state.

The timing output section 11 is inputted with the opening/closing detection signal S6 from the opening/closing detection sensor 5 to provide an output to the peak detection section 12 during a time Tj after the lapse of a time Ti from the point of time at which the chopper 3 is brought from its closed state to its opened state, that is, for a time corresponding to the period K1'. The times Ti and Tj are selected such that the time Tj is shorter than the opening/closing period Tc and is in a range in which the detection of the maximum value V1 and the minimum value V2 of the output signal S2 is sufficiently possible. In the period K1 outputted by the timing output section 11, the maximum value V1 and the minimum value V2 are detected and held by the peak detection section 12 and are supplied as an output signal S3 to the operational processing section 13. The operational processing section 13 determines a differential temperature ΔT in accordance with the equation of

$$\Delta T = k(V1 - V2) \text{ (k: predetermined constant)}$$

and operates the temperature Ta of the object to be detected in accordance with

$$Ta = Tc + \Delta T$$

by use of a chopper temperature Tc inputted from the chopper temperature detection element 4.

The timing output section 11 and the peak detection section 12 repeat a similar operation for each opening/closing operation of the chopper 3 and the operational processing section 13 successively determines the temperature Ta of the object to be detected. When the rotation of the moving part 6 over a predetermined range is completed, data of a series of temperatures Ta over the entire area or a thermal image signal S4 is outputted to the exterior. The thermal image signal S4 includes the temperatures of a wall surface in a detection area or information when a human body exists and is used for a radiation temperature detection, a human body detection or the like by an external processing.

Fig. 3 shows another embodiment of the present invention. In the figure, reference numeral 14 designates a reference signal detection section which detects and holds a signal from the band amplifier 10 in a period of time when the chopper 3 is maintained at a closed state by the drive control section 9. The detected reference signal S7 is outputted to the operational processing section 13. In Fig. 3, the same reference numerals as those used in Fig. 1 designates constituent elements which are the same as or correspond to those shown in Fig. 1.

Next, explanation will be made of the operation of the embodiment shown in Fig. 3. Fig. 4 is a timing chart for explaining the operation of the construction shown in Fig. 3. Before outputting driving signals to the chopper 3 and the rotating section 7, the drive control section 9 outputs a chopper driving signal S6 during a time Ta from an instant of time t0 to maintain the chopper 3 at a closed state. The closed state of the chopper 3 is maintained during a time Tb after the lapse of Ta. In this case, the amplitude of an output signal S2 of the band amplifier 10, irrespective of the state of the signal S2 before the instant of time t0, becomes zero not later than the lapse of the time Ta so that the signal S2 assumes a certain constant output level V0. The obtained state is continued during the time Tb. The reference signal detection section 14 is inputted with the output signal S2 in the time Tb so

that the value of the output signal S2 is held as a reference signal S7. Thereafter, the drive control section 9 outputs driving signals to the chopper 3 and the rotating section 7 to drive the chopper 3 and the moving part 6, thereby performing an operation similar to that explained in conjunction with Fig. 2. An output signal S3 from the peak detection section 12 and the reference signal S7 from the reference signal detection section 14 are inputted to the operational processing section 13. The operational processing section 13 uses the maximum value or minimum value V2 of the output signal S3 of the peak detection section 12 in the vicinity of an instant of time t2 and V0 of the reference signal S7 to determine a differential temperature T in accordance with the equation of

$\Delta T = k'(V0 - V2)$ (k': predetermined constant)

and further uses a chopper temperature Tc inputted from the chopper temperature detection element 4 to determine the temperature Ta of an object to be detected in accordance with

$$Ta = Tc + \Delta T.$$

A similar operation is repeated for each opening/closing operation of the chopper 3 as in the embodiment shown in Fig. 1 so that the operational processing section 13 successively determines the temperature Ta of the object to be detected.

The reason why V2 of V1 and V2 of the output signal S3 is used in the equation of $\Delta T = k'(V0 - V2)$ used by the operational processing section 13, is that it can generally be said from the response characteristic of the band amplifier 10 that V2 is superior to V1 in a proportional relation with a temperature signal detected by the pyroelectric thermal detection element 1. This will be explained using Fig. 5. In the case where a detection signal S1 from the pyroelectric thermal detection element 1 detects a fixed differential temperature, as shown by a characteristic L1 indicated by solid line in Fig. 5, an output signal S2 of the band amplifier 10 takes an output as shown by a characteristic L1'. In the case where the detection signal S1 has a characteristic L2 shown by broken line, the output signal S2 of the band amplifier 10 takes a characteristic L2'. Now provided that the value of the characteristic L2 is 1/2 that of the characteristic L1 at an instant of time t3, the output signal S2 cannot sufficiently follow the detection signal S1 in the vicinity of the instant of time t3 due to a response delay but exhibits a peak substantially corresponding to the detection signal S1 at an instant of time t4. Also, when the differential temperature ΔT becomes reverse with respect to the characteristic L1 as at an instant of time t5, that is, ΔT becomes negative, the output signal S2 has a considerably poor degree of correspondence to the detection signal S1 in the vicinity of the instant of time t5 but exhibits a peak substantially corresponding to the differential temperature ΔT at an instant of time t6. When ΔT becomes positive again at an instant of time t7, the output signal S2 exhibits a peak substantially corresponding to the differential temperature ΔT at an instant of time t8. Accordingly, it is apparent from the foregoing that in the case where the value of the differential temperature is greatly different in a detection rotation range and in particular in the case where the polarity of the differential temperature is different, the maximum value or minimum value V2 of the output signal S2 of the band amplifier 10, which value is a peak value in the vicinity of an instant of time when the chopper is brought from a closed state to an opened state, is superior in a proportional relation with the differential temperature to be detected.

From the above, the value of (V0 - V2) is generally smaller than that of (V1 - V2) obtained in the case of Fig. 2 (about 1/2 in the case where a differential temperature is fixed) but provides a differential temperature ΔT which has a higher precision as compared with that obtained in the case of Fig. 2.

In the drive control section 9, the time Ta and the time Tb can be realized easily by providing a first timer and a second timer which operates after the completion of the first timer. If the response characteristic of the band amplifier 10 is considered, it is preferable that the time Ta is made longer than a time from the point of time when the chopper 3 is brought to a closed state and to the point of time when the output signal S2 of the band amplifier 10 becomes completely zero. In general, the time Ta longer than two times as large as the opening/closing period Tc of the chopper 3 is enough. The noise resistance can be improved in such a manner that when the output signal S2 of the band amplifier 10 is inputted, the reference signal detection section 14 reads the output signal S2 plural times to determine an average value which is in turn provided as a reference signal S7.

In the present embodiment, the operational processing section 13 uses V2 of the output signal S3 of the peak detection section 12 but does not use V1 thereof. Accordingly, there may be used a construction in which the maximum value or the minimum value detected by the peak detection section 12 is only V2. For example, the timing output section 11 is constructed such that the period K1' in Fig. 4 when the peak detection section 12 detects the maximum value or the minimum value of the output signal S2 of the band amplifier 10 is only in the vicinity of an instant of time tl, that is, the time Ti is made long and the time Tj is short. And, the peak detection section 12 is provided with a polarity detecting section inputted with a signal from the band amplifier 10 for detecting the polarity of the signal from the band amplifier 10 so that the maximum value is held when the polarity is positive and the minimum value is held when the polarity is negative. With such a construction, it is possible to detect the maximum value or minimum value V2 accurately.

In the foregoing, the thermal image detecting system according to the present invention has been

explained on the basis of the embodiments shown in Figs. 1 and 3. However, other constructions as mentioned in the following are possible.

In the foregoing embodiments shown in Figs. 1 and 3, the explanation has been made in conjunction with the case where the pyroelectric thermal detection element 1 is single in number. However, there can be employed a construction, as shown in Fig. 6, in which a plurality of (for example, eight) pyroelectric thermal detection elements 1a, 1b, 1c, --- are arranged in the form of a row to provide a pyroelectric thermal detection element group 15 so that the elements in the row form are approximately perpendicular to the rotation direction of the moving part 6 and band amplifiers and peak detection sections (and reference signal detection sections in the case of Fig. 3) are provided corresponding to the plurality of pyroelectric thermal detection elements 1a, 1b, 1c, --- with the same number as those elements, thereby providing a multi-channelling so that a two-dimensional thermal image signal is obtained as the thermal image signal S4. Provided that the number of elements in the pyroelectric thermal detection element group 15 is 8, the angle of view by the infrared ray transmitting lens 2 is 80°, a horizontal rotation range of the moving part 6 is 150° and the chopper 3 is opened/closed 64 times at the opening/closing frequency of 32 Hz, a two-dimensional thermal image signal including an area of 80° in an up/down direction and 150° in a right/left direction and including 8 pixels in a vertical direction x 64 pixels in a horizontal direction can be obtained in about 2 seconds.

The opening/closing detection sensor 5 in the embodiments shown in Figs 1 and 3 detects the actual opening/closing operation. Therefore, a failure of the chopper 3 can be detected simultaneously if whether or not the opening/closing detection signal S6 of the opening/closing detection sensor 5 is normal is detected by the timing output section 11. Also, an approximately similar operation is possible even if the opening/closing detection sensor is not used in order to simplify the system and the chopper driving signal S6 is thereinstead used as an input signal of the timing output section 11. In this case, considering a response delay time for the chopper driving signal S5 of the chopper 3, that is, Td in Figs. 2 and 4, Tj + Td is used in lieu of Tj.

Though the opening/closing of the chopper 3 in the embodiments shown in Figs. 1 and 3 is controlled by the chopper driving signal S5 of the drive control section 9, the chopper can be provided with closing means for closing a path of infrared rays to the pyroelectric thermal detection element at the time of no supply of a current to the chopper 3. In this case, it is possible to prevent an unnecessary infrared ray signal from entering the pyroelectric thermal detection element 1 in a period of time when the detection of a thermal image is not conducted. Also, when the reference signal detection section 14 detects the reference signal S7 in the embodiment of Fig. 3, the supply of a current to the chopper 3 by the drive control section 9 to bring the chopper 3 into a closed state becomes unnecessary, thereby attaining power saving and the prevention of unnecessary temperature rise. Further, the time Ta in Fig. 4 can be shortened as a result, thereby contributing to the shortening of a time of repetition of the detection of a thermal image.

In the embodiments shown in Figs. 1 and 3, the chopper temperature detection element 4 for detecting the temperature of the chopper 3, that is, a reference temperature is provided the moving part 6. This chopper temperature detection element 4 is necessary in the case where when the thermal image signal S4 is to be obtained, the temperature of an object to be detected itself is determined and a small change in characteristic of a signal detected by the pyroelectric thermal detection element 1 due to a change in reference temperature is corrected. However, in the case where a thermal image based on a temperature ΔT of a difference from the chopper temperature suffices, the chopper temperature detection element 4 can be omitted.

In addition to the above, the peak detection section 12 in the embodiments shown in Figs. 1 and 3 can be constructed as follows.

The peak detection section 12 can be constructed by a pair of analog peak hold sections for holding the maximum value and the minimum value (or V1 and V2) of an output signal of the band amplifier 10 respectively and a time instant detection section for detecting a temporal relationship in sequence between the detection of the maximum value and the detection of the minimum value (or a relationship in sequence between t1 and t2) so that the outputs of the pair of analog peak hold sections and the output of the time instant detection section are inputted to the operational processing section 13 to determine a differential temperature ΔT. Alternatively, the peak detection section 12 may be constructed by an A/D conversion section for sequentially converting an output signal of the band amplifier 10 into a digital value, a pair of digital peak hold sections for holding, the digital value outputted by the A/D conversion section, as the maximum value when the digital output value is larger than the preceding values and as the minimum value when the digital output value is smaller than the preceding values, and a time instant detection section for detecting a temporal relationship in sequence between the detection of the maximum value and the detection of the minimum value so that the output of the A/D conversion section, the outputs of the pair of digital peak hold sections and the output of the time instant detection section are inputted to the operational processing section 13 to determine a differential temperature ΔT. Thus, the peak detection section 12 can be constructed by either an analog circuit or

a digital circuit. Which of the analog circuit and the digital circuit should be used in the construction of the whole of the system, can be selected properly.

The pair of digital peak hold sections mentioned above can be constructed to hold an average value between the output value of the A/D conversion section and the previous maximum or minimum value as a new maximum value when the output value of the A/D conversion section is larger than the previous maximum value and as a new minimum value when the output value of the A/D conversion section is smaller than the previous minimum value. Also, the peak detection section 12 can be constructed by an A/D conversion section for sequentially converting an output signal of the band amplifier 10 into a digital value, an average value holding section for operating an average value between the preceding output value of the A/D conversion section and the present output value thereof and holding the average value, a pair of digital peak hold sections for detecting the maximum value and the minimum value of an output value of the average value holding section and holding them, respectively, and a time instant detection section for detecting a temporal relationship in sequence between the detection of the maximum value and the detection of the minimum value. Each of the two means including the averaging process as mentioned above brings about a small detection error from the ideal maximum value and minimum value but provides an effect that the influence of noises such as power supply noises, in particular, peak noises at the time of detection can be reduced greatly, thereby enhancing the practical precision of detection.

Claims

1. A thermal image detecting system comprising:

   a moving part (6) including a pyroelectric thermal detection element (1) having an electric characteristic which changes in response to infrared rays, a chopper (3) for opening/closing a path of infrared rays from an object to be detected to said pyroelectric thermal detection element, and a chopper temperature detection element (4) for detecting the temperature of said chopper;

   rotating means (7) for rotating said moving part around a predetermined rotation axis;

   a drive control section (9) for driving said chopper and said rotating means;

   a band amplifier (10) for amplifying a detection signal from said pyroelectric thermal detection element;

   timing output means (11) for outputting a signal synchronous with an opening/closing operation of said chopper;

   a peak detection section (12) for successively holding the maximum value and the minimum value of a signal from said band amplifier in accordance with an output of said timing output means; and

   an operational processing section (13) inputted with a signal from said peak detection section to perform an operational processing to a thermal image signal on the basis of the detection signal and a difference between said maximum value and said minimum value and a detection signal of said chopper temperature detection element.

2. A thermal image detecting system comprising:

   a moving part (6) including a pyroelectric thermal detection element (1) having an electric characteristic which changes in response to infrared rays, a chopper (3) for opening/closing a path of infrared rays from an object to be detected to said pyroelectric thermal detection element, and a chopper temperature detection element (4) for detecting the temperature of said chopper;

   rotating means (7) for rotating said moving part around a predetermined rotation axis;

   a drive control section (9) for driving said chopper and said rotating means;

   a band amplifier (10) for amplifying a detection signal from said pyroelectric thermal detection element;

   a reference signal detection section (14) for detecting a signal from said band amplifier in a period of time when said chopper is maintained at a closed state by said drive control section;

   timing output means (11) for outputting a signal synchronous with an opening/closing operation of said chopper;

   a peak detection section (12) for holding the maximum value and the minimum value of a signal from said band amplifier in accordance with an output of said timing output means; and

   an operational processing section (13) inputted with a reference signal from said reference signal detection section and a signal from said peak detection section to perform an operational processing to a thermal image signal on the basis of the detection signal and a difference between said maximum value or minimum value and said reference signal and a detection signal of said chopper temperature detection element.

3. A thermal image detecting system according to Claim 1, wherein a plurality of said pyroelectric thermal detection elements (1a — 1n) are arranged in the form of a row to provide a pyroelectric thermal detection element group (15), and said band amplifiers (10) and said peak detection sections (12) are provided corresponding to said plurality of pyroelectric thermal detection elements with the same number as those elements,

output signals from the plurality of peak detection sections being inputted to said operational processing section (13) to obtain a two-dimensional thermal image signal.

4. A thermal image detecting system according to Claim 2, wherein a plurality of said pyroelectric thermal detection elements (1a --- 1n) are arranged in the form of a row to provide a pyroelectric thermal detection element group (15), and said band amplifiers (10), said peak detection sections (12) and said reference signal detection sections (14) are provided corresponding to said plurality of pyroelectric thermal detection elements with the same number as those elements, output signals from the plurality of reference signal detection sections and the plurality of peak detection sections being inputted to said operational processing section (13) to obtain a two-dimensional thermal image signal.

5. A thermal image detecting system according to Claim 1 or 2, wherein said timing output means (11) includes means which is inputted with a chopper driving signal from said drive control section (9) for driving said chopper (3) and outputs a timing signal for detection of the maximum value or the minimum value in said peak detection section (12).

6. A thermal image detecting system according to Claim 1 or 2, wherein said moving part (6) includes an opening/closing detection sensor (5) for detecting the opening/closing of said chopper (3), and said timing output means (11) includes means which is inputted with an opening/closing detection signal from said opening/closing detection sensor and outputs a timing signal for detection of the maximum value or the minimum value in said peak detection section (12).

7. A thermal image detecting system according to Claim 1 or 2, wherein said chopper (3) is provided with closing means for closing the path of infrared rays to said pyroelectric thermal detection element (1) at the time of no supply of a current to said chopper.

8. A thermal image detecting system according to Claim 2, wherein said drive control section (9) includes a first timer and a second timer which operates after the completion of said first timer, so that said drive control section maintains said chopper (3) at a closed state during the period of said first timer and provides an output to said reference signal detection section (14) during the period of said second timer to cause said reference signal detection section to detect a reference signal from said band amplifier (10), and wherein after the completion of said second timer, said drive control section causes said rotating means (7) to rotate said moving part (6) around said predetermined rotation axis while causing an opening/closing operation of said chopper.

9. A thermal image detecting system according to Claim 8, wherein the timer period of said first timer of said drive control section (9) is longer than at least two times as large as the opening/closing period of said chopper (3).

10. A thermal image detecting system according to Claim 2 or 8, wherein said reference signal detection section (9) includes averaging means inputted with the signal from said band amplifier plural times in a closed state of said chopper (3) to calculate an average value of the plural detection signals, said average value being provided as the reference signal.

11. A thermal image detecting system according to Claim 2, wherein said timing output section (11) provides an output in a period of time in the vicinity of an instant of time of the next change from a closed state of said chopper (3) to an opened state thereof for the opening/closing operation of said chopper, said peak detection section (12) includes polarity detecting means for detecting the polarity of the signal from said band amplifier (10), and said peak detection section is inputted with the signal from said band amplifier in a period of time when said timing output means provides the output and holds the maximum value when the polarity of the signal inputted from said band amplifier is positive and the minimum value when the polarity of the signal inputted from said band amplifier is negative.

12. A thermal image detecting system according to Claim 1 or 2, wherein said peak detection section (12) includes a pair of analog peak hold sections for holding the maximum value and the minimum value of a signal from said band amplifier (10) respectively and a time instant detection section for detecting a temporal relationship in sequence between the detection of the maximum value and the detection of the minimum value.

13. A thermal image detecting system according to Claim 1 or 2, wherein said peak detection section (12) includes an A/D conversion section for sequentially converting a signal from said band amplifier (10) into a digital value, a pair of digital peak hold sections for holding, the digital value outputted by the A/D conversion section, as the maxi-

mum value when the digital output value is larger than the preceding values and as the minimum value when the digital output value is smaller than the preceding values, and a time instant detection section for detecting a temporal relationship in sequence between the detection of the maximum value and the detection of the minimum value.

14. A thermal image detecting system according to Claim 13, wherein said pair of digital peak hold sections hold an average value between the output value of said A/D conversion section and the previous maximum or minimum value as a new maximum value when the output value of said A/D conversion section is larger than the previous maximum value and as a new minimum value when the output value of said A/D conversion section is smaller than the previous minimum value.

15. A thermal image detecting system according to Claim 1 or 2, wherein said peak detection section (12) includes an A/D conversion section for sequentially converting a signal from said band amplifier (10) into a digital value, an average value holding section for operating an average value between the preceding output value of said A/D conversion section and the present output value thereof and holding the average value, a pair of digital peak hold sections for detecting the maximum value and the minimum value of an output value of said average value holding section and holding them, respectively, and a time instant detection section for detecting a temporal relationship in sequence between the detection of the maximum value and the detection of the minimum value.

FIG. 1

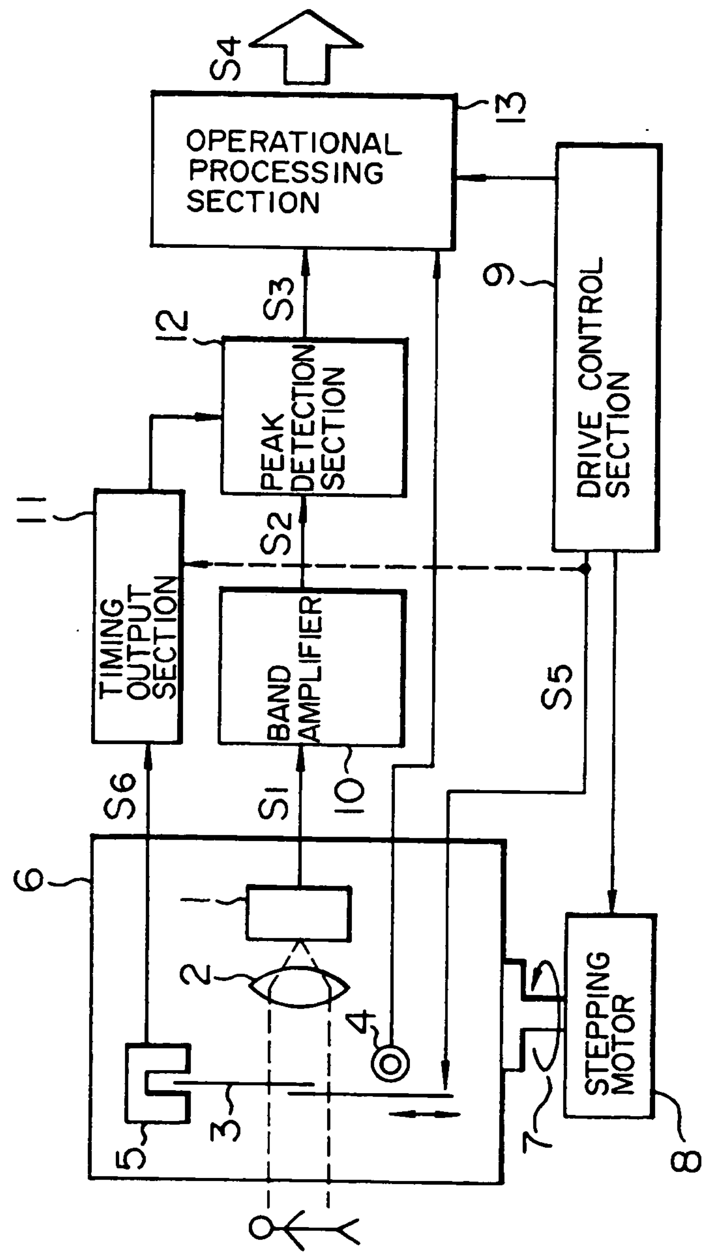

OPERATIONAL PROCESSING SECTION
PEAK DETECTION SECTION
BAND AMPLIFIER
TIMING OUTPUT SECTION
DRIVE CONTROL SECTION
STEPPING MOTOR
S1
S2
S3
S4
S5
S6

FIG. 2

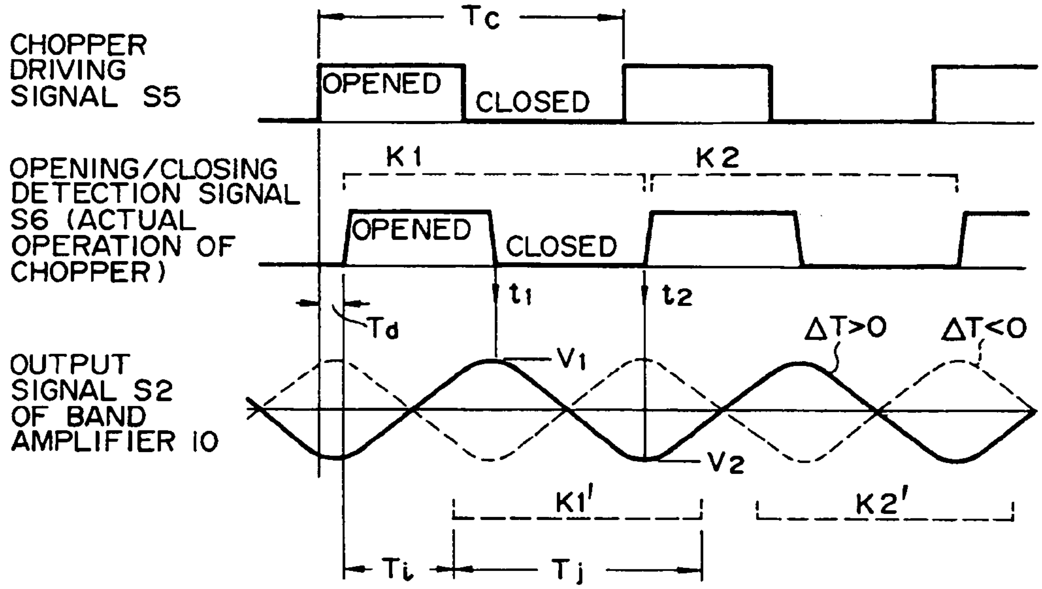

Tc
CHOPPER DRIVING SIGNAL S5
OPENED
CLOSED
OPENING/CLOSING DETECTION SIGNAL S6 (ACTUAL OPERATION OF CHOPPER)
K1
K2
t1
t2
Td
OUTPUT SIGNAL S2 OF BAND AMPLIFIER 10
V1
V2
ΔT>0
ΔT<0
K1'
K2'
Ti
Tj

FIG. 4

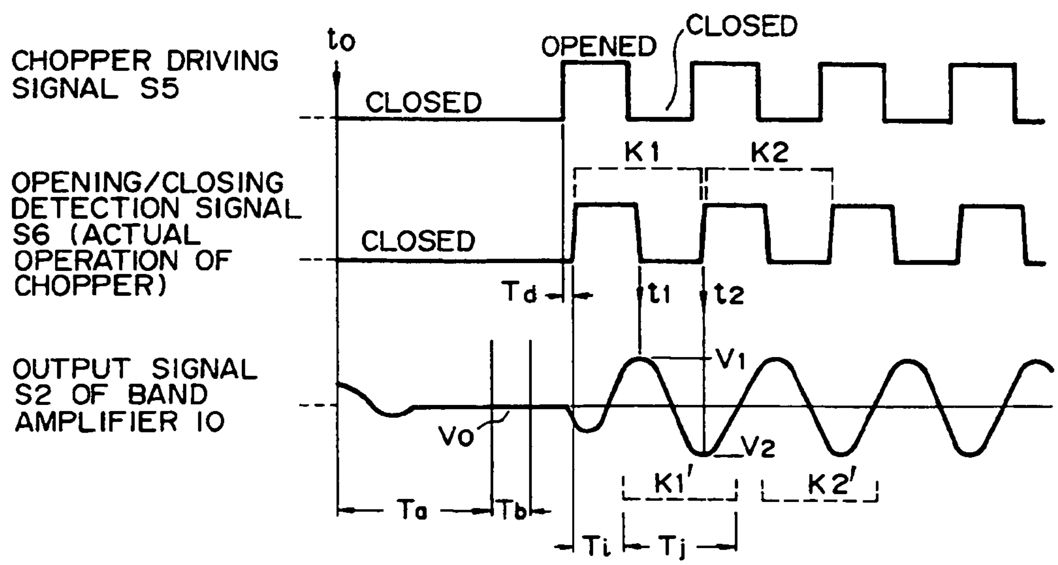

to
CHOPPER DRIVING SIGNAL S5
CLOSED
OPENED
CLOSED
OPENING/CLOSING DETECTION SIGNAL S6 (ACTUAL OPERATION OF CHOPPER)
CLOSED
K1
K2
Td
t1
t2
OUTPUT SIGNAL S2 OF BAND AMPLIFIER 10
V1
V2
Vo
K1'
K2'
Ta
Tb
Ti
Tj

FIG. 3

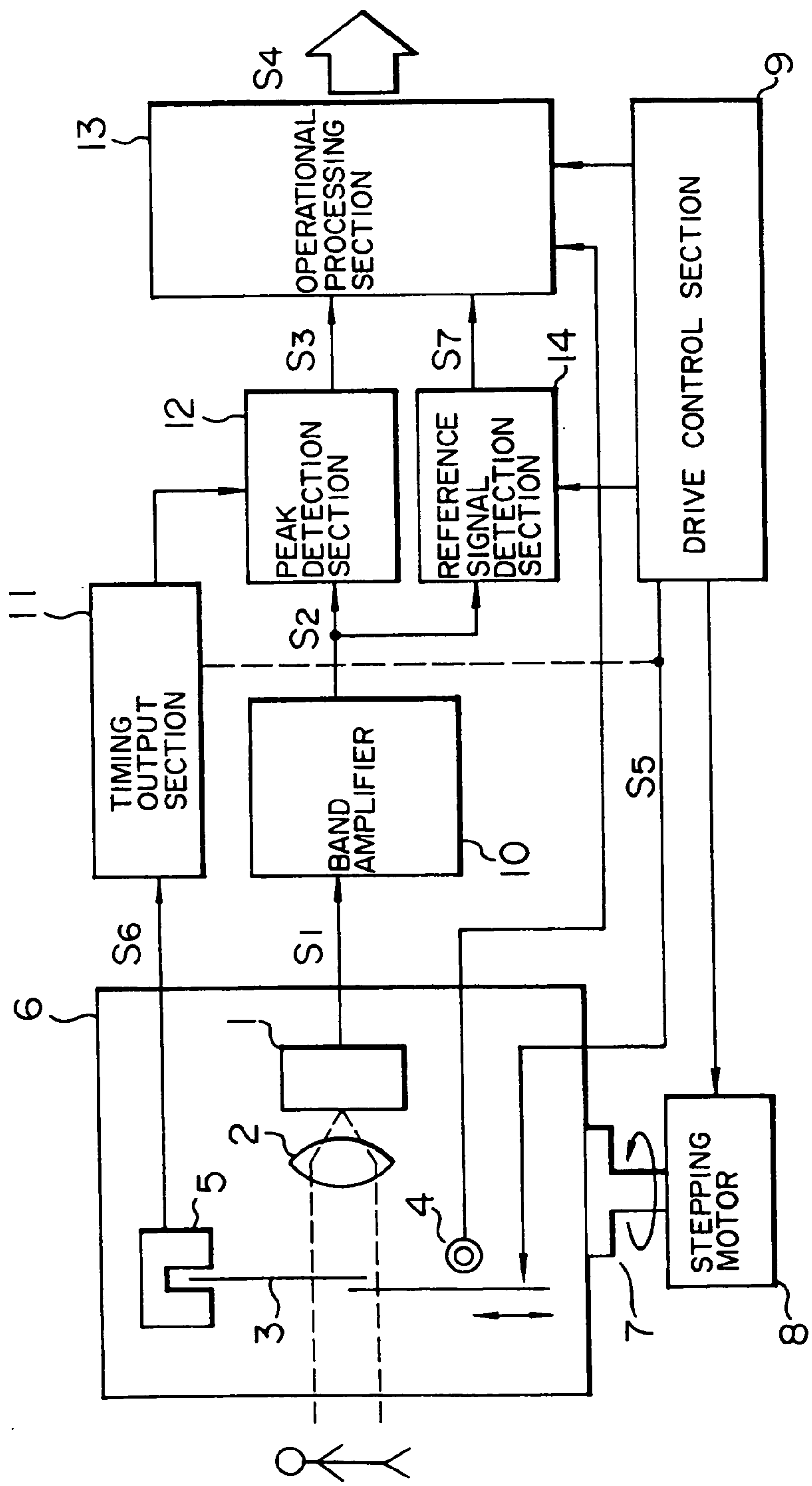

OPERATIONAL PROCESSING SECTION
PEAK DETECTION SECTION
REFERENCE SIGNAL DETECTION SECTION
DRIVE CONTROL SECTION
TIMING OUTPUT SECTION
BAND AMPLIFIER
STEPPING MOTOR
S1
S2
S3
S4
S5
S6
S7
1
2
3
4
5
6
7
8
9
10
11
12
13
14

FIG. 5

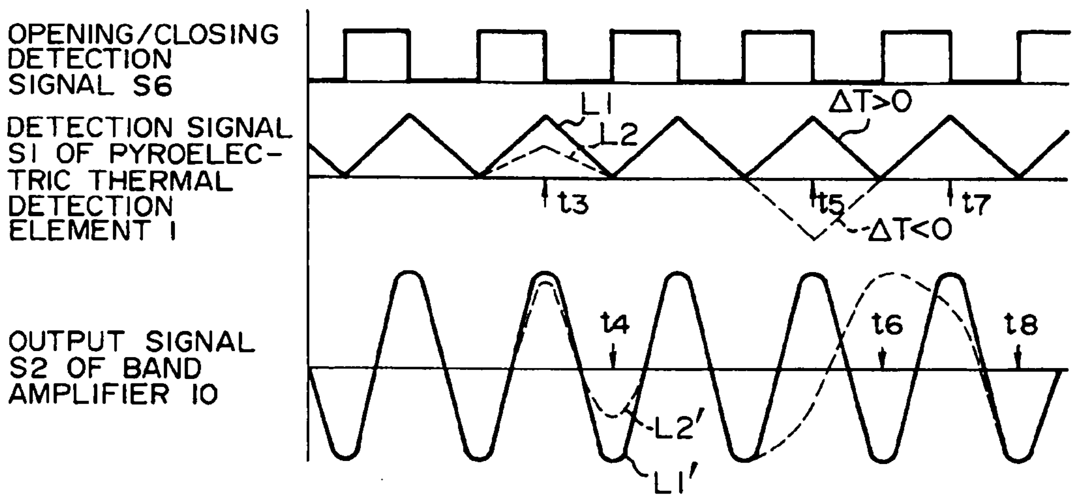
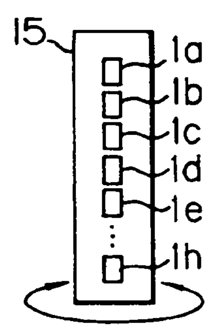

OPENING/CLOSING DETECTION SIGNAL S6
DETECTION SIGNAL S1 OF PYROELECTRIC THERMAL DETECTION ELEMENT 1
OUTPUT SIGNAL S2 OF BAND AMPLIFIER 10
L1
L2
ΔT>0
ΔT<0
t3
t4
t5
t6
t7
t8
L2'
L1'

FIG. 6


15
1a
1b
1c
1d
1e
1h

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 7327

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 098 402 (TOKYO SHIBAURA DENKI KABUSHIKI KAISHA) * abstract; figures 3-5 * * page 8, line 1 - line 18 *	1	G01J5/62
Y	US-A-5 001 657 (YAGURA ET AL.) * abstract; figures 1,9 * * column 4, line 54 - column 5, line 2 *	1	
A	EP-A-0 233 711 (MB GROUP PLC.) * abstract; figures 2,7 *	3,4	
A	US-A-3 536 917 (DESVIGNES) * claim 1; figure 3 *	3,4,10	
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 230 (P-599)28 July 1987 & JP-A-62 044 634 (FUJITSU LTD.) 26 February 1987 * abstract *	1	
A	US-A-3 350 562 (FLINT) * the whole document *		TECHNICAL FIELDS SEARCHED (Int. Cl.5) G01J G08B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	15 DECEMBER 1993	DANIELIDIS S.

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

& : member of the same patent family, corresponding document